QUALITY AND YIELD OF TREE-HARVESTED MACADAMIA NUTS

ARS 42-196
April 1972

AGRICULTURAL RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

ABSTRACT

Macadamia nuts, generally, are considered ready for harvest only after they fall naturally from the trees. Consequently, the main harvesting systems being used or explored are for natural fall nuts. In this study of one variety in one orchard, nuts removed from the trees even early in the harvest season had quality and yield equal to conventionally ground-harvested nuts. Insect damage was also less. These findings support the study of a system in which nuts are removed from the trees before natural fall.

QUALITY AND YIELD OF TREE-HARVESTED MACADAMIA NUTS[1]

By Gordon E. Monroe, Tung Liang, and Catherine G. Cavaletto[2]

INTRODUCTION AND OBJECTIVES

The macadamia nut industry in Hawaii is growing rapidly. Total acreage increased from 3,820 acres in 1960 to 8,725 acres in 1970.[3] Production, processing, and marketing procedures are well established and satisfactory solutions developed for most of the problems that have arisen in the industry. One problem that has lingered, however, is that of harvesting. With less than one-half of the 1970 acreage in production and a decreasing labor supply, this problem can only become worse if harvesting practices are not changed.

All nuts are harvested from the ground after natural fall, and with the exception of one large orchard, they are all picked up by hand (fig. 1). Hand harvesting in mature orchards accounts for over half the total labor required for production.[4]

Since commercial production began in the early 1930's, macadamia nuts are generally considered ready for harvest only after they fall naturally to the ground.[5] Thus tradition has implied, if not established, that nuts on the tree are immature. Because flowering occurs over a long period (3 months or more), a similar time period is indicated for ripening on the tree. However, if nuts remain on the tree for some time after ripening, then at least some part of the crop on the tree at a given time would be ripe.

Assuming a fairly constant time from flowering to maturity, the part ripe at any time would depend mainly on the flowering pattern and how long ripe nuts remain on the tree. For example, if all nuts, after ripening, remain on the tree for a time equal to or greater than the total flowering season, the entire crop for that season would be ripe on the tree when the last nuts became ripe.

If the assumption is correct that macadamia nuts are generally not mature until they fall, only two main systems exist as alternatives to conventional hand harvesting. One, a mechanical sweep and pickup system similar to those used on walnuts and pecans, is being used to partly harvest one large orchard in Hawaii. The other, which has been investigated for several years but is not yet used commercially, incorporates nets suspended below the tree canopy. Both systems have certain drawbacks, mainly in high initial investment and maintenance costs. Shake harvesting is being investigated as a third alternative, but this system is basically unsound if nuts are immature until they fall naturally.

This study was conducted to learn more about the maturity of nuts on the tree and how tree harvesting, as opposed to ground harvest, may influence the quality and yield of processed kernels. Specific objectives were to (1) determine the part of nuts on the tree that are mature at different times throughout the harvesting season, and (2) compare the quality and yield of tree-picked nuts with that of ground-harvested nuts.

---

[1] Based on cooperative research by the Hawaii Agricultural Experiment Station (Journal Paper No. 1354) and the United States Department of Agriculture.

[2] Monroe is agricultural engineer, Fruit and Vegetable Harvesting Investigations, Agricultural Engineering Research Division, Agricultural Research Service, stationed at the Agricultural Engineering Department, University of Hawaii, now located at the Southeastern Fruit and Tree Nut Research Station, Byron, Ga.; Liang, associate agricultural engineer, Department of Agricultural Engineering, University of Hawaii; and Cavaletto, assistant food technologist, Department of Food Science and Technology, University of Hawaii.

[3] 1970 Statistics of Hawaiian Agriculturee, p. 17. Hawaii Crop and Livestock Reporting Service, July 1971.

[4] Keeler, J.T., and Fukunaga, E.T. The Economic and Horticultural Aspects of Growing Macadamia Nuts Commercially in Hawaii. Univ. of Hawaii Agr. Econ. Bul. No. 27, 47 pp. 1968.

[5] Hamilton, R.A., and Fukunaga, E.T. Growing Macadamia Nuts in Hawaii. Hawaii Agr. Expt. Sta. Bul. No. 121, 51 pp. 1959.

Figure 1.—Conventional ground harvesting of macadamia nuts.

METHODS AND PROCEDURES

Early in September 1970, a study was initiated on forty-eight 18-year-old *Macadamia integrifolia* trees, variety Keauhou or 246, in Waimanalo to determine the ratio of mature to immature nuts on the trees at different times throughout the harvest season. At this time only a few nuts had fallen. Shell color, which has a definite relationship to kernel development, was used to indicate maturity of the nuts. (Generally, dark shelled nuts are mature and light shelled nuts immature.) A cork borer was used to inspect the shell color of nuts on the trees. All nuts tested had dark shells. An experiment was then designed to compare the quality and yield of tree-picked nuts with that of ground-harvested nuts.

Experimental Design

The 48 trees that supplied nuts for this experiment had previously been used in a 6-treatment, 8-replication fertilizer experiment. Large variations were expected among trees from the different fertilizer treatments, so a complete randomized block design could not be used. The trees within any one of the fertilizer treatments were assumed approximately homogeneous. A new treatment with six replicates was formed by randomly selecting one tree from each fertilizer treatment. A total of eight new treatments were formed using this procedure. Different tree harvest dates were assigned to seven of the new treatments, and trees in the remaining new treatments were conventionally ground-harvested and used as checks.

Harvesting

Intervals between harvest dates were roughly 2 weeks, and both tree and ground harvests were done on selected dates. Starting with the first harvest on September 8, approximately 40 pounds of in-husk nuts were tree harvested from each of the trees by randomly removing nuts by hand and with long-handled rakes. No further samples were taken from these trees throughout the season. On the same day, nuts that appeared to have fallen recently were collected from beneath the ground-harvest trees, and then all old nuts (left from the previous season), leaves, and trash were raked out beyond the drip line of these trees. At the second harvest date, September 17, nuts were tree harvested from another block of tree-harvest trees, and all nuts were collected from beneath the same previously ground-harvested trees.

This procedure was continued through four more harvests (October 1, October 15, October 29, and November 12). Trees for the seventh tree-harvest treatment were not used because only a few nuts remained on them. The ground-harvest trees were harvested three more times (November 27, December 10, and December 28) for a total of nine ground harvests, which included essentially all the crop for the season from these trees.

Processing

Harvested nuts were placed in coarse mesh fiber produce bags to prevent heat buildup. They were taken to the University of Hawaii and husked the same day they were harvested. All nuts from the ground harvests were dark shelled. A few (less than 0.2 percent) of the tree-harvested nuts from the first two harvest dates had light shells, but none thereafter.

Following husking, the nuts were dried for 1 week in 55-gallon drums by blowing ambient air through them. Air drying was followed by drying at 100° F. for 2 days, then 125° F. for 5 days. This drying procedure resulted in a kernel moisture of approximately 1.2 percent. The nuts from each tree were divided into samples of 100 nuts each and weighed. After weighing, the nuts for an individual tree were combined, cracked, and roasted in coconut oil at 270° F. for 15 minutes in a Hotpoint model HK3 deepfryer.[6] Immediately after roasting, the kernels were drained and centrifuged to remove excess oil.

Grading

The oil content of the macadamia kernel is an indicator of maturity, with mature nuts having the highest oil content. High-quality kernels generally have high-oil content. In addition, high-quality roasted kernels are not overbrown, unevenly browned, shriveled, or damaged. Two grading methods, visual and flotation, were used to evaluate the roasted kernels in this study. Visual grading is subjective, but considers quality factors other than oil content; whereas flotation is objective, but only indicates oil content.

Kernels from each tree were divided visually into grades (No. 1 = mature kernels, light uniform color; No. 2 = kernels not fully developed, dark or not uniformly brown, but usable; No. 3 = very badly shriveled, very dark or seriously damaged kernels, unusable). Weights were taken for each grade. In addition, separate weights were taken in each grade for kernels damaged by the Southern green stinkbug. To minimize the subjectivity of this grading method, the same person graded all the kernels in this study.

[6] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

Flotation grading[7] is based on specific gravity (sp. gr.) of the kernels; those with high oil content float in a lower specific gravity solution than those with low oil content. Normally, flotation grading is done on raw kernels, but in this study roasted kernels were used so that the same kernels could be used for both grading methods and any possible effects of wetting and redrying on the roasting characteristics of the kernels could be avoided. Previous studies[8] showed a negligible increase (76.95 to 77.25 percent) in oil content during oil roasting; however, we thought that this very small gain in oil content would not appreciably affect flotation separation.

The flotation method of Moltzau and Ripperton[7] was modified by using two salt solutions of 1.012 and 1.062 sp. gr. Kernels were first placed in the 1.062 sp. gr. solution; the sinkers were graded No. 3 and the floaters No. 1 and 2. The floaters were then drained and immediately placed in the 1.012 sp. gr. solution; sinkers were No. 2 grade and floaters were No. 1. Following the flotation procedure, the kernels were dried at 125° F. and then weights were taken for each grade.

RESULTS

Multiple linear regression analysis was performed for two independent and 10 dependent variables. The data and regression lines are shown in figures 2 to 5. The independent variables were harvest date and harvest method, with harvest method being either ground harvest (solid lines) or tree harvest (broken lines). The dependent variables were (1) percentages of harvests, by weight, of No. 1, No. 2, and No. 3 quality grades of nuts by both visual and flotation grading procedures (figs. 2 and 3); (2) harvest yield as represented by the dried, in-shell weight per 100 nuts (fig. 4); and (3) percentages of harvests, by weight, of stinkbug damaged No. 1, No. 2, and No. 3 visually graded kernels (fig. 5).

The regression lines provide good fit to the data and therefore can be used to interpolate the value of any item to be expected for nuts harvested by either method at a specific harvest date. However, these lines do not indicate what part of the total crop any specific value applies to.

Figure 6 shows the percentage of the total crop that had fallen throughout the season. From these data, the percentage of the crop remaining on the tree at various times was derived.

Quality

The percentage of No. 1 grade kernels (by both visual and flotation grading methods) resulting from ground harvest of the entire crop is shown on the far right in figure 7 at the ninth and last harvest. Although nine ground harvests were used to collect the entire crop, these frequent harvests are not the commercial practice. More probable, the commercial practice is three to four harvests and the quality of nuts harvested at these longer intervals is likely to be slightly lower. Longer harvest interval results in greater chance for spoilage and rodent damage.

Also shown in figure 7 is the percentage of No. 1 nuts (by flotation and visual grading) for the entire crop if nuts are ground harvested to a certain date and then all remaining nuts are tree harvested.

Apparently, under the conditions of this study, nuts could be harvested from the tree at the beginning of the season or at any other time of the season in combination with ground harvest with no resulting loss in quality.

Yield

The weight of nuts in-shell gives an indication of yield. Weight per 100 nuts in-shell for the entire crop after ground harvest(s) to a date and then a tree harvest of all remaining nuts (fig. 8) remained virtually constant. These data support other evidence that the nuts on the tree were mature early in the season.

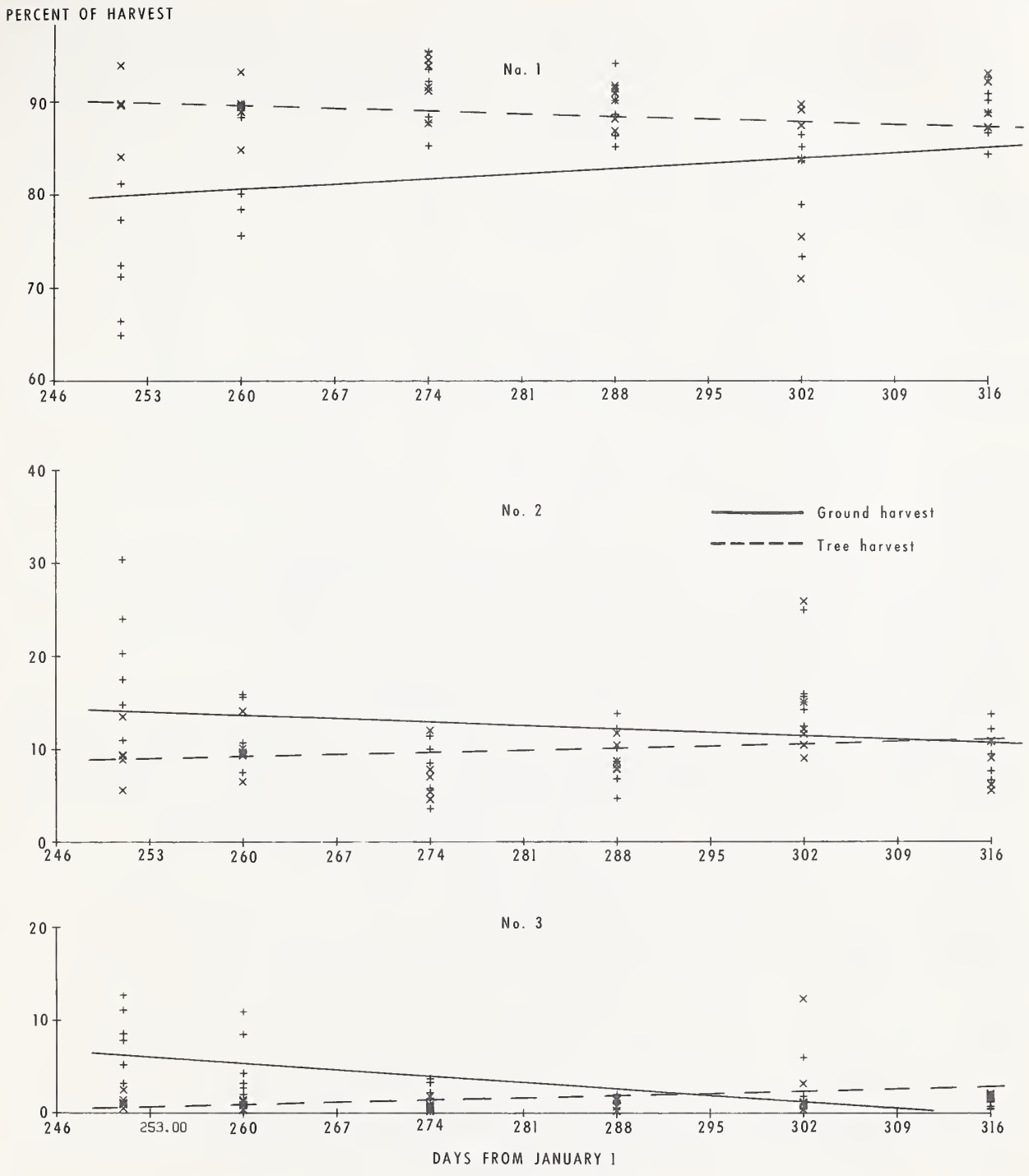
Insect Damage

The study orchard was located in an area where the Southern green stinkbug was a serious problem. This insect damages the macadamia kernel. Of the total crop, by weight, ground harvested, 12 percent was insect damaged, but only 8.5 percent of the tree-harvested crop (including the small amount that had already fallen to the ground) was damaged. In locations where stinkbug infestation is a problem, these data give further support for early harvesting.

---

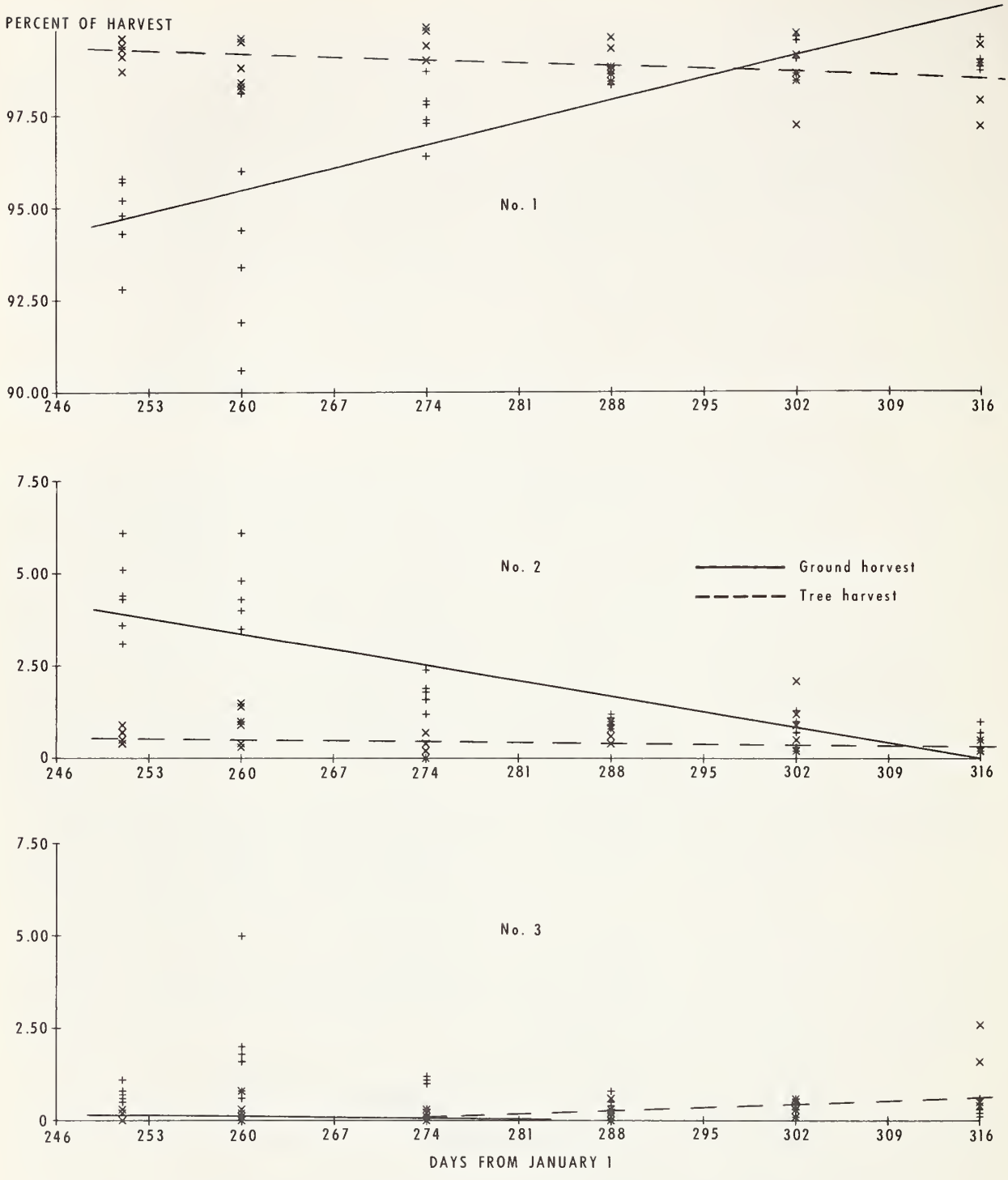
[7] Moltzau, R.H., and Ripperton, J.C. Processing of the Macadamia. Hawaii Agr. Expt. Sta. Bul. No. 83, pp. 14-17. 1939.

[8] Cavaletto, C., Cruz, A. Dela, Ross, E., and Yamamoto, H.Y. Factors Affecting Macadamia Nut Stability. I. Raw Kernels. Food Technol. 20(8): 108-111. 1966; II. Roasted Kernels. Food Technol. 20(9): 123-124. 1966.



NO. 1 = MATURE KERNELS, LIGHT UNIFORM COLOR; NO. 2 = KERNELS NOT FULLY DEVELOPED, DARK OR NOT UNIFORMLY BROWN, BUT USABLE; NO. 3 = VERY BADLY SHRIVELED, VERY DARK OR SERIOUSLY DAMAGED KERNELS, UNUSABLE.

Figure 2.—Percentage of harvests, by weight, of No. 1, No. 2, and No. 3 quality graded kernels, visual grading. No. 1 = mature kernels, light uniform color; No. 2 = kernels not fully developed, dark or not uniformly brown, but usable; No. 3 = very badly shriveled, very dark or seriously damaged kernels, unusable.



SEE FIGURE 2 FOR DEFINITION OF GRADES.

Figure 3.—Percentage of harvests, by weight, of No. 1, No. 2, and No. 3 quality graded kernels, flotation grading. (See figure 2 for definition of grades.)

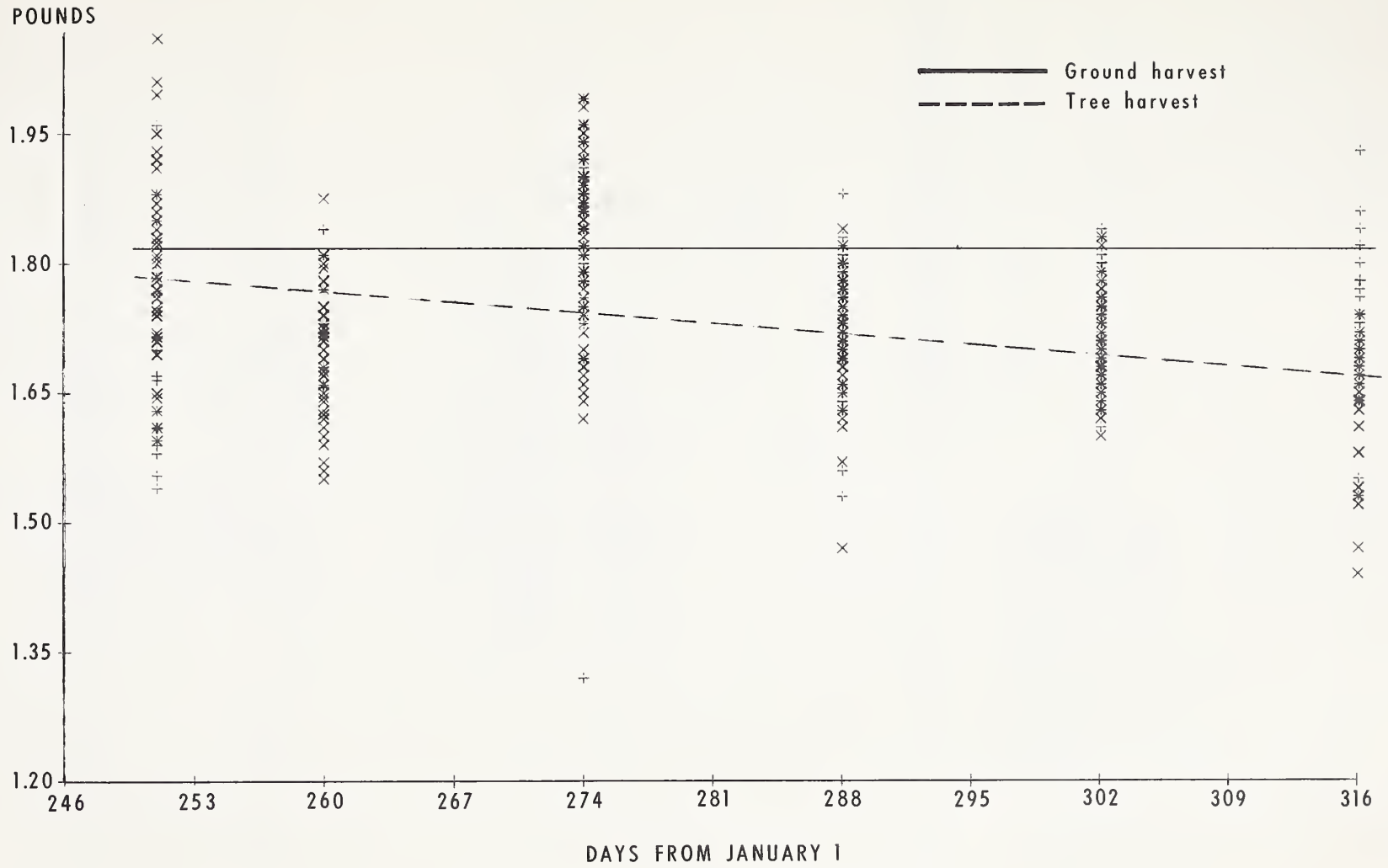
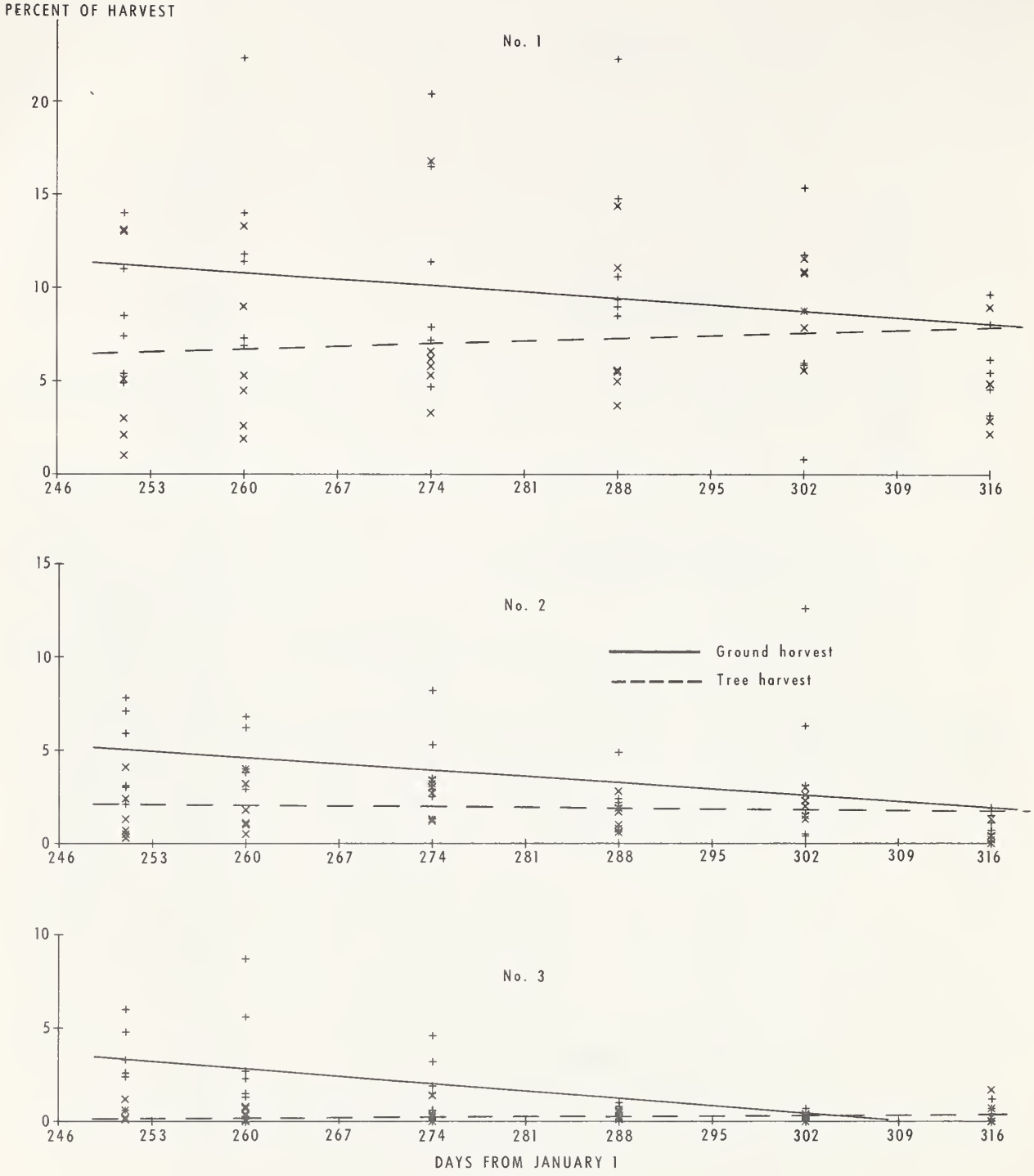


Figure 4.—Harvest yield, by weight per 100 dried nuts in shell.



SEE FIGURE 2 FOR DEFINITION OF GRADES.

Figure 5.—Percentage of harvests, by weight, of stinkbug damaged kernels, visual graded No. 1, No. 2, and No. 3. (See figure 2 for definition of grades.)

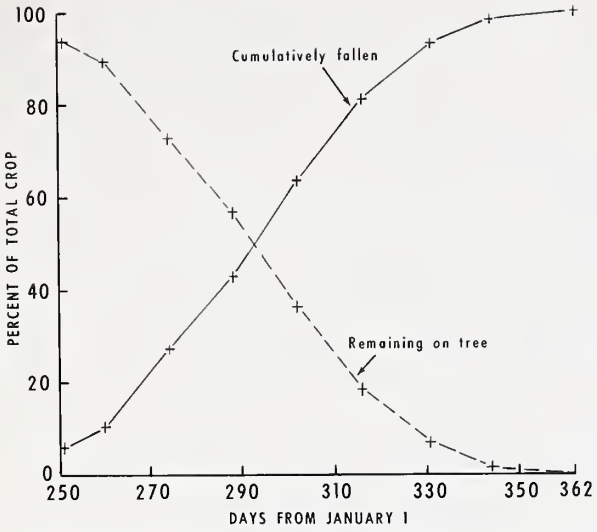
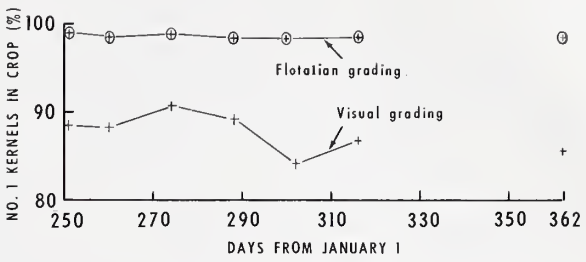
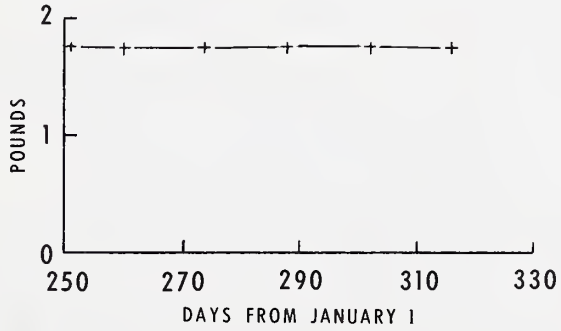


Figure 6.—Percentage of the total crop cumulatively fallen and the corresponding percentage remaining on the tree (Data based on the weight of dried in-shell nuts.)



EACH POINT REPRESENTS CUMULATIVE GROUND HARVEST TO THAT DATE AND THEN REMOVAL OF ALL NUTS REMAINING ON THE TREE. POINTS AT FAR RIGHT ARE FOR THE ENTIRE CROP BY GROUND HARVEST.

Figure 7.—Percentage of entire crop, by weight, that are No. 1 kernels, by flotation and visual grading. Each point represents cumulative ground harvest to that date and then removal of all nuts remaining on the tree. Points at far right are the entire crop by ground harvest.



EACH POINT REPRESENTS THE ENTIRE CROP YIELD AFTER GROUND HARVEST (S) TO THAT DATE AND THEN REMOVAL OF ALL NUTS REMAINING ON THE TREE.

Figure 8.—Weight per 100 dried nuts in-shell. Each point represents the entire crop yield after ground harvest(s) to that date and then removal of all nuts remaining on the tree.

SUMMARY AND CONCLUSIONS

Short supply and high cost of labor for harvesting macadamia nuts are serious problems that will become worse unless new harvesting methods are developed. Macadamia nuts, generally, are considered mature only after they fall naturally from the trees, so the main harvesting methods existing or being studied are for natural fall nuts. In one other method under consideration, the nuts are removed from the trees before natural fall. Information is needed on the quality and yield of tree-harvested nuts before appraising this harvesting method. A study designed to evaluate tree-harvested macadamia nuts was conducted on a single variety (Keauhou) in one orchard during the 1970 harvest season. Under these conditions, essentially the entire crop could have been harvested at one time at the beginning of the harvest season with kernel quality and yield comparable to that from a series of ground harvests over a 3½-month period. These results indicate the need for similar investigations of macadamia nuts under different conditions of location, season, and variety to more completely evaluate the tree-harvesting method.

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
BELTSVILLE, MARYLAND 20705